EP Note 23

Fermilab
ES&H Section

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FROM: Bill Griffing, ES&H Section Head

SUBJECT: THE GROUNDWATER MONITORING STRATEGY FOR NuMI

You will find the subject report attached to this memo. The Environmental Protection Group and Radiation Protection Group of the ES&H Section have put together this report to document the Data Quality Process for establishing the groundwater monitoring system for your experiment.

If you have any questions, please contact Paul Kesich at ext. 4495.

Encl. As stated

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File: Environmental Monitoring/Surveillance

The Groundwater Monitoring Strategy For NuMI
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Introduction

In order to operate the NuMI experiment, and at the same time ensure that impacts resulting from its operation would reliably stay within all groundwater standards, the ES&H Section and the NuMI project have agreed upon and articulated a rational monitoring strategy, including the means of its implementation.

The role of the ES&H Section is to confirm that the groundwater resources of the state are protected, as mandated by all applicable laws and regulations, and to ensure that a surveillance-monitoring network based on sound sampling protocol, capable of obtaining valid and meaningful data that is representative of the receptor, is properly designed. It was determined that establishment of a surveillance monitoring program for detecting any impacts from operations of this project could be incorporated into, and implemented as part of, the laboratory's site-wide approach for groundwater protection, as set forth in Fermilab's Environmental Management System and still allow the NuMI project to operate according to its design limits, and within an acceptable cost.

The development of the surveillance monitoring network was accomplished in conformance with DOE standards for protecting the public and the environment, and Fermilab's site requirements for establishment and maintenance of a site wide surveillance monitoring program and operation in accordance with the laboratory's mission.

Network Design

The design of a ground water surveillance monitoring network was based on a systematic process to assure that samples are representative of the resource and the impact of the projects operations, and produce data that would effectively meet the needs for demonstrating that the activation of water and soil/rock outside the tunnel of the NuMI project and the subsequent leaching of radionuclides into resource (Class I) groundwater from NuMI operations would not violate Illinois' groundwater standards. Meeting these requirements was accomplished through the use of the Data Quality Objective (DQO) process recommended by DOE for establishing and maintaining such programs. The DQO process has been employed for the design of environmental data collection and monitoring systems, and is quite suitable for the design of an effective ground water surveillance-monitoring network.

The basic steps of the DQO process used in developing the ground water monitoring strategy and network for the NuMI project is composed of the following elements:

1. The Problem
2. Identify the Decision
3. Identify the Inputs to the Decision
4. Define the Boundaries of the Problem
5. Develop a Decision Rule
6. Specify the Tolerable Limits on Decision Errors
7. Optimize the Design for Obtaining Data

The Problem:

1. Monitoring of the ground water for accelerator-produced radionuclides (^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, ^{60}Co) must be performed to determine whether these byproducts of experimental operations are being released from the vicinity of the NuMI experimental tunnel.

It is necessary to maintain one monitoring well (S-1274) immediately down-gradient of and as close as technologically feasible to the carrier tunnel and the pre-target enclosure, screened in the upper 20 feet of the Upper Bedrock Aquifer, to detect levels of accelerator-produced radionuclides that would indicate releases from the experimental tunnel and to determine if those releases exceed the ground water quality standards set forth in 35 IAC 620.410(e).

The location and screen interval for the monitoring well was decided from an analysis of the geology and hydrogeologic characteristics of the geologic units that make up the materials in which the NuMI tunnel was constructed. The type of potential interactions that could occur along the tunnel length and engineering controls (ie. shielding, beam controls, induced inward gradient) were also considered in making the determination.

The Upper Bedrock Aquifer is located in dolomite and shale materials with major hydrogeologic properties controlled by secondary permeability (ie. fractures, bedding planes, solution channels). The depths of these features were determined during characterization studies along with the natural gradient as well as current induced gradients. The tunnel maintains an induced inward gradient throughout the majority of its length (approximately 3800 ft). This induced inward gradient was modeled and was determined to capture water from the area where potential activation would occur throughout the majority of the length of the tunnel. The only area of question was limited to an approximately 200 ft section at the intercept of the glacial deposits and bedrock. This area is in the central portion of the carrier tunnel.

2. Monitoring of the potentiometric surface of the Upper Bedrock Aquifer must be performed to determine whether drawdown from continued pumping of ground water infiltrating into the NuMI tunnel could affect other local uses of the aquifer.

It is necessary to maintain 23 piezometers along the line of the tunnel, screened at various elevations within the Upper Bedrock Aquifer and the lower confining unit, to detect drops in the potentiometric surface of ground water within the geologic units that form the Upper Bedrock Aquifer and the lower confining unit, that would adversely impact current uses.

The location and screen intervals for the piezometers were decided from a similar analysis as was performed in determining the location and screen interval for the monitoring well.

Identify the Decision:

The information obtained from the installed monitoring network whenever the wells/piezometers are sampled will establish:

1. Whether the concentrations of accelerator-produced radionuclides are above detectable limits set for environmental samples (approximately 1.0 pCi/ml ^{3}H and 0.1 pCi/ml ^{22}Na), indicating that a potential release has occurred and triggering an investigation.

2. Whether the concentrations of accelerator-produced radionuclides are above the ground water quality standards set forth in 35 IAC 620.410(e), which would trigger the determination of the average annual concentration and whether it exceeded a dose equivalent to the total body, or to any internal organ, greater than 4 mrem/year. If two or more radionuclides were present, the sum of their dose equivalent to the total body, or to any internal organ, would be calculated according to 35 IAC 620. 410(e)(2) to determine whether it exceeded 4 mrem/year. If the radionuclide is tritium, the average annual concentration assumed to produce a total body or organ dose of 4 mrem/year is 20 pCi/ml.

3. Whether the potentiometric surface drawdown caused from pumping of water inflowing into the tunnel has or is approaching the point where it will impact current use of the aquifer (onsite or offsite supply wells).

Identify the Inputs to the Decision:

Inputs to the design of the surveillance monitoring system included:

- the nature of the facility,
- the type of contaminant(s) that may be released to the subsurface,
- the local ground water flow system and how it responds to seasonal or episodic perturbations,
- the frequency by which decisions need to be taken and whether responses are needed, and
- the consequences of not making appropriate and timely responses.

Information for the above input bullets was determined from extensive subsurface investigation and computer modeling.

Define the Boundaries of the Problem:

The surveillance-monitoring network for the NuMI project was designed with the follow boundaries:

- Spatial and temporal boundaries were considered with the physical location of the facilities and the proposed length for running the experiment (approximately 10 – 20 years).
- The legal and political barriers were considered to determine the potential for offsite impacts. A project and monitoring network strategy overview was presented to the Illinois Environmental Protection Agency.
- Cost effectiveness was considered since the NuMI project encompasses a very large area in both the horizontal and vertical planes. The network was designed to minimize potentially excessive costs from continuous monitoring of very small increments of depth and lateral space without significant reduction in effectiveness.

Develop a Decision Rule:

If any level of accelerator-produced radionuclide is detected above the method detection level, then the following actions will be taken:

1. The Radionuclide Analysis Facility will be contacted to determine if the potential for analytical error is possible.
2. A follow-up confirmation sample will be taken immediately.
3. If the sample concentration is determined to be correct, the concentration of each detectable radionuclide will be used to determine if the ground water quality standards outlined in 35 IAC 620.410(e) have been exceeded.
    a. If the levels are below the 4 mrem / year limit:
        -an annual average concentration will be calculated and maintained through future sampling. For non-detects a value of ½ of the method detection limit will be used to calculate the yearly average.

b. If the levels are above the 4 mrem / year limit:
   -the laboratory will develop and implement a corrective action program (35 IAC 620.302(c)).

If drawdown of the potentiometric surface resulting from continued pumping of infiltration water reaches a point where current uses of the aquifer will be impacted:

1. An investigation will be conducted to determine the full extent of impact.
2. Potential corrective actions including modification of use or supply will be examined.

<u>Specify the Tolerable Limits on Decision Errors:</u>
The ground water monitoring network will be sampled initially on a quarterly basis according to the yearly sample schedule. This frequency may be modified as necessary in future years (due to changes in operation parameters or examination of analytical history).

Ground water levels are taken both manually and with Solinst transducers. Manual levels are taken monthly with an electronic measuring tap with a minimum measure of 1 / 100th of an inch. Electronic transducers measure values every 10 minutes to tolerances found in the equipment manual.

Representative samples will be assured by following the procedures outlined in the Environmental Protection Procedures Manual, Procedure 109 – Source Specific Wells.

Samples will be analyzed according to established procedures of the onsite Radionuclide Analysis Facility.

Standard limits for concentrations of radionuclides are available in the regulations (35 IAC 620).

Impacts to use are determined from location of use, depth of withdrawal and equipment tolerances.

Besides ground water sampling, samples of effluent from ground water infiltrating into the tunnel, which is pumped to the surface and discharged into surface water, will also be sampled as part of the Accelerator Division monitoring program according to their sample schedule and the Memorandum of Understanding between AD and NuMI. The ES&H Section will sample water overflow from the surface pond on an annual basis.

<u>Optimize the Design for Obtaining Data:</u>

Through the DQO process a designed monitoring network has been established to measure ground water levels and concentrations of accelerator-produced radionuclides. The established network is responsive to the needs and constraints identified and balance those considerations with cost. The features of the monitoring network determined through this process were sufficient enough in detail to construct the system and for development of the sampling plan.

The monitoring network consists of one monitoring well (S-1274) for obtaining ground water representative of formation water in the vicinity of the area of concern and determining concentrations of accelerator produced radionuclides. It also consists of 23 piezometers for obtaining information on the potentiometric surface of the geologic units that make up the aquifer through which the NuMI tunnel was constructed. Details of the network can be found in referenced material.

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